

M1.D

[1]

M2.D

[1]

M3.A

[1]

M4. (a)  $C_3H_8O + 4O_2 \rightarrow 3CO_2 + 3H_2O$  (1) (or multiple)

1

(b) (i)  $\frac{1.45}{58}$  (1) = 0.0250 (1)  
allow 0.025  
allow conseq on wrong M,  
 $\frac{1.45}{58.1}$  C.E.  
1.45/100, CE;  $\frac{1.45}{58.1}$  C.E.

(ii) heat released =  $mc\Delta T$   
=  $100 \times 4.18 \times 58.1$  (1)  
if 1.45 used in place of 100 CE = 0  
= 24300 J (1) (or 24.3kJ)  
allow 24200 to 24300  
ignore decimal places  
units tied to answer  
if use  $0.1 \times 4.18 \times 51.8$  allow  $\frac{1}{2}$  for 24.3 with no units

(iii)  $\frac{24.3}{0.0250} = -972 \text{ (kJ mol}^{-1}\text{) (1)}$   
*allow -968 to -973*  
*allow +972*  
*allow conseq*  
*allow no units*  
*penalise wrong units*

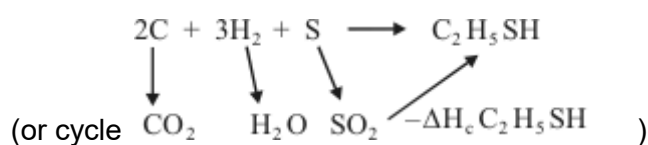
5

- (c) (i) Heat loss **(1)** or energy loss  
*do not allow incomplete combustion*
- (ii) *Difference*: more negative **(1)** (or more exothermic)  
*QoL mark*

*Explanation*: heat (or energy) released when water vapour condenses **(1)**  
 or heat/energy required to vaporise water  
 or water molecules have more energy in the gaseous state

3

(d)  $\Delta H = \Sigma \Delta H_{\text{reactants}} - \Sigma \Delta H_{\text{products}}$  **(1)**



$$\begin{aligned}
 &= (2 \times -394) + (3 \times -286) + (-297) - (-1170) \text{ (1)} \\
 &= -773 \text{ (1)}
 \end{aligned}$$

*ignore units even if wrong*  
*Allow 1/3 for +773*

3

[12]

M5.B

[1]

**M6.C**

[1]

- M7.** (a) (Enthalpy change) when 1 mol **(1)** of a compound is formed from its constituent elements **(1)** in their standard states **(1)**

3

*Allow energy or heat, Ignore evolved or absorbed  
Mark each point independently*

- (b) (The enthalpy change for a reaction is) independent of the route **(1)**

1

- (c)  $\Delta H_r = \sum \Delta H_f \text{ products} - \sum \Delta H_f \text{ reactants}$  **(1)**  
 $= [(3 \times -286) + (3 \times -394)] - (-248)$  **(1)**  
 $= -1792$  **(1)** (kJ mol<sup>-1</sup>)

*Deduct one mark for each error to zero*

3

[7]

**M8.C**

[1]

- M9.** (a) They are elements **(1)**  
*Ignore irrelevant comments*

1

- (b) Enthalpy change **(1)**  
*or heat energy change or heat change or  $\Delta H$  or any named enthalpy change C.E. if change not mentioned*

Independent of route **(1)**

*OR depends on initial and final states*

*Only give second mark if first mark awarded except allow if energy used instead of enthalpy*

2

- (c)  $\Delta H = \sum \Delta H_f^\ominus(\text{products}) - \sum \Delta H_f^\ominus(\text{reactants})$  **(1)** **(Or a cycle)**  
 $= 2 \times -242 + \frac{1}{2} \times -394 - (-365)$  **(1)** **(also implies first mark)**  
 $= -316 \text{ kJ mol}^{-1}$  **(1)**

3

*Ignore no units penalise wrong units*

*+316 scores 1/3*

[6]

**M10.** (a) Heat energy change **(1)**

*Not energy on its own*

measured at constant pressure **(1)**

*Mark separately, ignore constant temperature statements*

2

- (b) (i) Enthalpy change when 1 mol of a substance (or compound / product) **(1)** is formed from its constituent elements **(1)** in their standard states **(1)** under standard conditions **(1)**

*Mark separately*

- (ii)  $2\text{Na(s)} + \text{S(s)} + 2\text{O}_2(\text{g}) \rightarrow \text{Na}_2\text{SO}_4(\text{s})$

*Balanced (1) State symbols (1), but only if all species are correct*

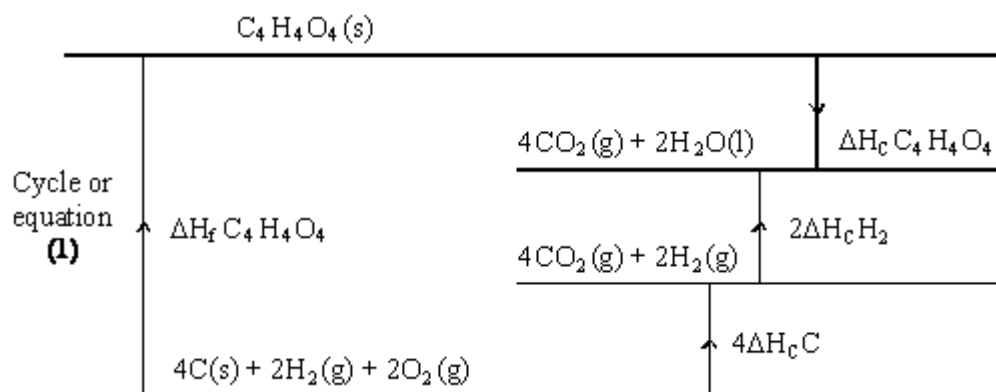
*Allow  $\frac{1}{8} \text{S}_8(\text{s})$*

5

- (c) Enthalpy change is independent of reaction route **(1)**

*Penalise incorrect additional statements*

(d)



$$-1356 + (2 \times 285.8) + (4 \times 393.5) + \Delta H_c C_4H_4O_4 = 0$$

$$\Delta H_f = -789.6 \text{ kJ mol}^{-1}$$

*If answer is incorrect:*

*Score +789.6 two marks*

*Score ( $\times 1$ ); ( $\times 2$ ) and ( $\times 4$ ) for species - one mark*

*If an incorrect negative answer given check for AE for loss of one mark*

3

[11]